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Abstract Proceedings Signal and Imaging Sciences Workshop CASIS Workshop 2006

R. Roberts

November 9, 2006

Abstract Proceedings Singal and Imaging Sciences Workshop
CASIS Workshop 2006
Livermore, CA, United States
November 16, 2006 through November 17, 2006

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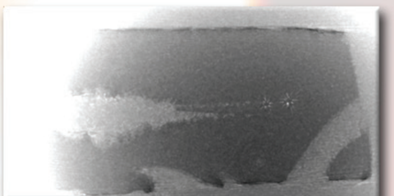
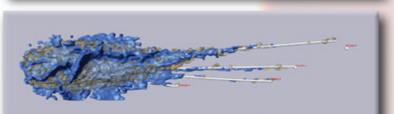
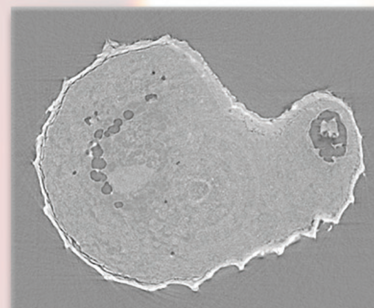
ABSTRACT PROCEEDINGS

Signal and Imaging Sciences Workshop





CASIS Workshop 2006



Thursday, November 16, 2006

Friday, November 17, 2006

Sponsored by

Lawrence Livermore National Laboratory

Engineering Directorate

Center for Advanced Signal and Image Sciences (CASIS)

Steve Azevedo, Randy Roberts, Co-Directors

http://casis.llnl.gov

Center for Advanced Signal and Image Sciences

ENGINEERING

WELCOME

On behalf of the entire team of the Center for Advanced Signal and Image Sciences (CASIS) and the LLNL Engineering Directorate, we want to welcome you to this Thirteenth Annual Signal and Image Sciences Workshop at the Lawrence Livermore National Laboratory!

This year, as in the past 12 years, we are pleased to bring you an impressive array of presentations in the areas of signal processing, imaging, communications, controls, along with associated fields of mathematics, statistics, and computing sciences.

The Engineering Directorate (Steve Patterson, AD, and Greg Suski, DAD/S&T) has generously supported this workshop every year with the knowledge that these disciplines are critically important to virtually all laboratory programs. We are always impressed with the diversity of scientific and technical talent (not just from Engineering!) who participates. The workshop is a forum for all laboratory employees and guests to share their work with colleagues, and perhaps find answers to tough technical problems.

On the next page is the list of the speakers who have presented the keynote addresses in past eight years; all are demonstrated leaders in this field, and we have been fortunate to have them here. (By the way, we have videotapes or DVD's of all these talks for anyone who is interested.) This year, we add to this list with two distinguished speakers who both have LLNL ties. We welcome back to LLNL our former CASIS Director, Dr. Jim Candy, who has been on sabbatical this last year at Cambridge University. In so many ways, Jim has had a hand in cultivating and nurturing signal processing at LLNL, and we are happy to have him back to present his work on "A Bayesian Approach to Nonlinear Statistical Signal Processing" Thursday at 9AM. On Friday at 9AM, we welcome Professor Sanjit Mitra who has collaborated on several laboratory projects in the past, and also sent some of his students to be LLNL employees. A current IEEE Award winner and industry leader, Sanjit will present "Recent Research Results in Image and Video Processing".

Speaking of keynote presenters, enclosed in this booklet is a recent article written by our keynote speaker at last year's CASIS Workshop, Dr. James L. Flanagan. We obtained permission from Dr. Flanagan and the Tau Beta Pi publishers to share with us his thoughts on US competitiveness in science, engineering and technology. His article is very timely, and reminds us to find ways to engage in "knowledge creation" as well as forming the industry and university partnerships that will encourage innovation. We all have a part to play in shaping this future.

We are holding the CASIS Workshop in a new venue this year -- the recently renovated Building 482 Auditorium. Many thanks go to the NIF Directorate and Associate Director Ed Moses for allowing us access to this facility.

Finally, we must again recognize that this workshop has benefited from the outstanding support of our truly professional staff, especially Deana Eshpeter and Vickie Abreu with help from Dora Da Rosa, as well as the Engineering Art & Edit Team of Debbie Ortega, Irene Chan, and Kathy McCullough. We could not have put on this event without them. Thank you!

We are excited to bring you this workshop, and hope that you enjoy the next two days of presentations. This is a perfect time to learn about your colleagues' work, and exchange ideas openly with the participating scientists and engineers. Thank you for attending this year's Workshop, and please fill in the feedback/survey form at the back of this book so we can make the CASIS Workshop even better next year!

Stephen Azevedo and Randy Roberts
C.A.S.I.S. Co-Directors
http://casis.llnl.gov

CASIS

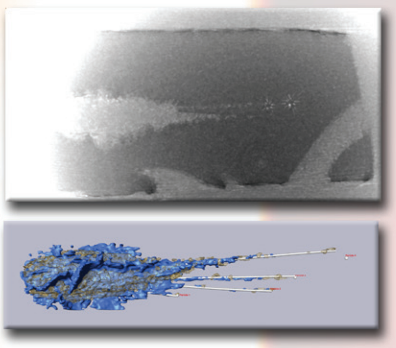
Center for Advanced Signal and Image Sciences
Previous Keynote Speakers

Year	Speaker	Title
1998	Dr. Anthony Devaney, Northeastern University	Diffraction Tomography
	Dr. Ronald Bracewell, Stanford University	Detection of Nonsolar Planets by Spinning Infrared Interferometer
1999	Dr. Bernard Widrow, Stanford University	A Microphone Array for Hearing Aids
	Dr. Avi Kak, Purdue University	A Retrospective on Computer Vision Research
2000	Prof. Simon Haykin, McMaster University	Adaptive Systems for Signal Processing
	Dr. Christian Pichot, University of Nice	Subsurface Tomography Using Ultra-Wide Band Systems
2001	Dr. James Greenleaf, Mayo Foundation	Vibro-Scoustography: Ultrasonic Imaging Without Speckle
	Prof. A. Paulraj, Stanford University	Multiple Input - Multiple Output (MIMO) Wireless: The New Frontier
2002	Dr. Alan Witten, University of Oklahoma	Expedition Adventure: Using Geophysics to Find Dinosaurs, Pirate Ships and Cavemen
	Dr. Leon Cohen, University of New York	Time-Frequency Description of Signals
2003	Dr. Thomas Budinger, UC Berkeley	Recent Advancements in Medical Imaging
2004	Prof. Alan Oppenheim, MIT	Things My Mother Never Told Me (About Signal Processing)
	Prof. James McClellan, Georgia Tech	Array signal Processing for Locating Buried Objects and Tracking Moving Targets
2005	Prof. James Flanagan, Rutgers University	Natural Interfaces for Information Systems

AGENDA

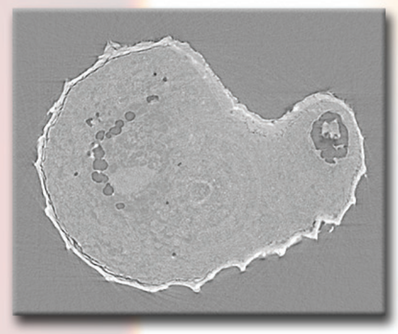
Signal and Imaging Sciences
Workshop

CASIS is a workshop for LLNL, UC community personnel, and others to share accomplishments, ideas, and areas of need in the Signal, Imaging and Communications Sciences



Tomographic slice (top) of "Wild 2" comet dust particles captured in a silicon-based aerogel by the NASA Stardust spacecraft and returned to earth in January 2006. A 3-D rendering (bottom) of the full reconstruction from LLNL's Xradia Micro-XCT scanner reveals the paths of the comet particles.

Image Credit: Nick E. Teslich Jr. and William D. Brown



Targets for high-energy-density physics experiments in the National Ignition Facility laser are about the size of a poppy seed. This image shows a tomographic slice of an actual poppy seed from LLNL's Xradia Micro-XCT scanner.

Image Credit: John D. Sain and Harry E. Martz, Jr.

November 16-17, 2006

Sponsored by the LLNL Engineering Directorate and the Center for Advanced Signal and Image Sciences (CASIS)

Center for Advanced Signal and Image Sciences

The background image is a simulated long-exposure image of a star and its planet (to the right). The spatially-filtered wavefront sensor for adaptive optics prevents aliasing in measuring Earth's atmospheric turbulence to produce improved correction, creating a dark region around the target star. High-contrast imaging with AO is being applied to the detection of extra-solar planets.

Image Credit: Lisa A. Poyneer and Bruce A. Macintosh

This work was performed under the auspices of the U.S. Department of Energy, National Nuclear Security Administration by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

AGENDA
Signal and Image Sciences Workshop
Center for Advanced Signal and Image Sciences
Lawrence Livermore National Laboratory

THURSDAY, NOVEMBER 16, 2006 BUILDING 482 AUDITORIUM

8:00 AM **Registration and Continental Breakfast**
8:45 AM **Opening Remarks, Introductions** .... **Stephen Azevedo, CASIS Director**
8:55 AM **Welcome from Engineering and NIF** .... **Dr. Steven Patterson, AD Engineering, and Dr. Ed Moses, AD NIF**
9:00 AM **Dr. James Candy, Keynote Speaker, Chief Scientist for Engineering, LLNL; Adjunct Professor, UC Santa Barbara**
A Bayesian Approach To Nonlinear Statistical Signal Processing

10:00AM **MORNING BREAK—Complimentary**

Analysis of Massive Datasets
Session Chair: Chandrika Kamath

10:30 AM Estimating Missing Features to Improve Multimedia Information Retrieval .... Nicole Love
10:45 AM Analysis of Rayleigh-Taylor Instability: Bubble and Spike Count .... Abel Gezahegne
11:00 AM Pattern Recognition for Massive, Messy Data .... Philip Kegelmeyer (Sandia)
11:15 AM Visualization and Analysis of 2D and 3D Image Data with VisIt .... Mark Miller
11:30 AM Visualization of Experimental and Numerical Data at the Sustained Spheromak Physics Experiment .... Carlos A. Romero-Talamás

11:45 AM **LUNCH BREAK—Complimentary**

Nondestructive Evaluation
Session Chair: Harry Martz

1:00 PM Morphological Algorithms for Non-Destructive Evaluation .... Siddharth Manay
1:15 PM Super-Resolution Algorithms for Ultrasonic Nondestructive Evaluation Imagery .... Grace A. Clark
1:30 PM Time Resolved Measurement of Transient Acoustic Waves Using a Frequency Domain Photoacoustic Microscopy System .... Oluwaseyi Balogun
1:45 PM Micron Scale Resolution of Structural Features in Mesoscale Material Systems Using Laser Based Acoustic Microscopy .... Oluwaseyi Balogun
2:00 PM Fusion of X-ray and Ultrasound Images for As-Built Modeling .... Grace A. Clark
2:15 PM Surface Acoustic Wave Microscopy of Optics .... Michael J. Quarry

2:30 PM **AFTERNOON BREAK—Complimentary**

Imaging Methodology
Session Chair: Mike Moran

3:00 PM Performance Modeling of the NIF Neutron Imaging System .... Carlos A. Barrera
3:15 PM Coherent Addition of Pulse for Energy (CAPE) Instrument and Data Fitting Model Study .... Michael Rushford
3:30 PM Curvature Wavefront Sensing Using an Extra-Focal Image and an Intra-focal Image of a Bright Star .... Donald Phillion
3:45 PM The Compact Compton Imager: A Spectroscopic, Large Field-of-View Gamma-Ray Camera .... Lucian Mihailescu
4:00 PM Distributed Object Classification in an Imaging Sensor Network .... Leo Szumel (UC Davis)
4:15 PM Virtual Geographic Routing .... Michael E. Goldsby (Sandia)

4:30 PM **ADJOURN**

AGENDA
Signal and Image Sciences Workshop
Center for Advanced Signal and Image Sciences
Lawrence Livermore National Laboratory

FRIDAY, NOVEMBER 17, 2006   BUILDING 482 AUDITORIUM

8:00 AM **Registration and Continental Breakfast**

8:50 AM **Opening Remarks, Introductions .... Randy Roberts, CASIS Co-Director**

9:00 AM **Professor Sanjit K. Mitra, Keynote Speaker, Department of Electrical Engineering–Systems, University of Southern California**

Recent Research Results in Image and Video Processing

10:00AM **MORNING BREAK—Complimentary**

NIF Optics Inspection
Session Chair: Laura Kegelmeyer

10:30 AM NIF Optics Inspection Analysis .... Laura Kegelmeyer
10:45 AM NIF Optics Damage Inspection Systems .... Alan Conder
11:00 AM Parallel Image Processing for NIF Optics Inspection .... Steve Glenn
11:15 AM Performance Improvements in NIF Optics Inspection Software .... Philip Fong
11:30 AM Ultrasonic Shear Wave Imaging of Optic Features .... Michael J. Quarry

11:45 AM **LUNCH BREAK—Complimentary**

Model-Based Signal Processing and Estimation
Session Chair: David Chambers

1:00 PM Detection of Seismic Events with Model-Based Signal Processing .... Arthur Rodgers
1:15 PM Model-Based Layer Estimation Using a Hybrid Genetic/Gradient Search Optimization Algorithm .... David H. Chambers
1:30 PM Introduction to Particle Swarm Optimization .... Sean K. Lehman
1:45 PM A Single-Layer Network of Unscented Kalman Filters Adaptively Fused by the Mixture-of-Experts Method .... Eric Breitfeller
2:00 PM Measurement Uncertainty for Automatic Alignment Algorithm .... Abdul Awwal
2:15 PM Spectral Analysis Options .... Karl Nelson

2:30 PM **AFTERNOON BREAK—Complimentary**

Image Processing and Analysis
Session Chair: Dave Paglieroni

3:00 PM Review of the State of the Art in Image Registration .... Judy Liebman
3:15 PM Progressive Dense Correspondence with Applications to Video Analysis .... Mark Duchaineau
3:30 PM A Linear Consolidation Approach for Automatically Extracting Roads of Variable Widths from Overhead Images .... Barry Y. Chen
3:45 PM Algorithms for Fast, Robust Model-Based Polygon Detection .... Siddharth Manay

4:00 PM **ADJOURN**

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Model-Based Signal Processing and Estimation — *David Chambers*

Image Processing and Analysis — *Dave Paglieroni*

Keynote Speakers

Dr. James V. Candy
and
Professor Sanjit K. Mitra

Center for Advanced Signal and Image Sciences

A Bayesian Approach to Nonlinear Statistical Signal Processing

Dr. James V. Candy
Chief Scientist for Engineering, LLNL
Adjunct Professor, UC Santa Barbara

In the real world, systems designed to extract signals from noisy measurements are plagued by errors due to constraints of the sensors employed, to random disturbances and noise and, probably most common, to the lack of precise knowledge of the underlying physical phenomenology generating the process in the first place!

Methods capable of extracting the desired signal from hostile environments require approaches that capture all of the a priori information available and incorporate them into a processing scheme. These approaches are typically model-based, employing mathematical representations of the component processes involved. However, the actual implementation enabling the processor evolves from the realm of statistical signal processing using a "Bayesian" approach.

In this lecture, Dr. Candy will discuss this combination of the Bayesian and model-based approaches to signal and image processing, thereby capturing the underlying physics, instrumentation and noise in the form of mathematical models from which the measured data evolved. He will present a unique perspective of signal processing from the Bayesian approach, starting with a brief tutorial of nonlinear statistical signal processing, through "simulation-based" (Monte Carlo) methods, and leading to the idea of a "particle filter", which is a discrete representation of a probability distribution. He will present applications that compare the performance of the particle filter designs with classical implementations (nonlinear model-based processors implemented using extended Kalman filters). This novel approach is much more of a modeler's rather than signal processor's tool, since we are working directly in the physics of the problem. *For a more complete synopsis of Dr. Candy's lecture, visit our web site at http://casis.llnl.gov*

Dr. James V. Candy recently returned to LLNL from a year-long assignment at the University of Cambridge (Clare Hall College) where he was elected as Visiting Fellow. He has been a researcher at LLNL since 1976, holding various positions including from Project Engineer for Signal Processing, Thrust Area Leader for Signal and Control Engineering, CASIS Founder and Director, and most recently Chief Scientist for Engineering. He has supported numerous programs with his research interests in Bayesian estimation, system identification, spatial estimation, signal and image processing, array signal processing, nonlinear signal processing, tomography, sonar/radar and biomedical applications.

Dr. Candy is a Fellow of the IEEE and a Fellow of the Acoustical Society of America (ASA). He received the IEEE Distinguished Technical Achievement Award for the "development of model-based signal processing in ocean acoustics." He was also recently selected as an IEEE Distinguished Lecturer for oceanic signal processing as well as presenting an IEEE tutorial on advanced signal processing available through their video website courses. Dr. Candy has published over 200 journal articles, book chapters, and technical reports, as well as written three texts in signal processing: "Signal Processing: the Model-Based Approach," (McGraw-Hill,1986), "Signal Processing: the Modern Approach," (McGraw-Hill, 1988), and "Model-Based Signal Processing," (Wiley/IEEE Press, 2006). He is currently the IEEE Chair of the Technical Committee on "Sonar Signal and Image Processing" and was the Chair of the ASA Technical Committee on "Signal Processing in Acoustics" as well as being an Associate Editor for Signal Processing of ASA (on-line).

Dr. Candy received his B.S.E.E. degree from the University of Cincinnati and his M.S.E. and Ph.D. degrees in Electrical Engineering from the University of Florida, Gainesville. He received a commission in the US Air Force in 1967 and was a Systems Engineer/Test Director from 1967 to 1971 before joining the laboratory. He has been an Adjunct Professor at San Francisco State University, the University of Santa Clara, and the UC Berkeley Extension, teaching graduate courses in signal and image processing. He is currently an Adjunct Full-Professor at the University of California, Santa Barbara.

Recent Research Results in Image and Video Processing

Professor Sanjit K. Mitra
Department of Electrical Engineering – Systems
University of Southern California

Many advances in digital image and video processing have facilitated the enormous growth of these disciplines in support of science, manufacturing and entertainment. In this presentation, Dr. Mitra will provide an overview of some recent research results in this vibrant field. He will address three specific areas that have particular relevance to laboratory data processing: image analysis, image filtering, and image and video compression. In image analysis, he will explore the areas of camera calibration, color image segmentation and image resizing. Topics discussed under the second category of image filtering will be impulse noise removal, color image filtering and contrast enhancement. Finally, in the third category, Dr. Mitra will address image compression using sub-band DCT (discrete cosine transform) techniques and using perfect-reconstruction IIR QMF (infinite impulse response, quadrature mirror filterbanks). He will also present rate-distortion analysis of images and videos.

Professor Sanjit K. Mitra is internationally known for his work in analog and digital signal processing and image processing. He has published over 600 papers, is the author or co-author of 12 books, and holds five patents. He is a member of the National Academy of Engineering, a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), the American Association for the Advancement of Science (AAAS), and the International Society for Optical Engineering (SPIE), and a member of the European Association for Signal, Speech and Image Processing (EURASIP).

This year, he received the 2006 James H. Mulligan, Jr. IEEE Education Medal for "outstanding contributions to electrical engineering education through pioneering textbooks, innovative laboratory development, and curriculum reform." He is the recipient of numerous other awards during his distinguished career at UC Santa Barbara, including the 1989 Alexander von Humboldt Foundation (Germany) Distinguished Senior U.S. Scientist, the IEEE Millennium Medal in 2000, and the 2002 Technical Achievement Award of EURASIP.

In 2006, Professor Mitra joined the Viterbi School at USC as the Stephen and Etta Varra Professor of Electrical Engineering (Systems). Professor Mitra received a B.S. with honors in Physics from Utkal University, India, in 1953, an M.S. in Radio Physics and Electronics from the University of Calcutta in 1956, and M.S. and Ph.D. degrees in Electrical Engineering from the University of California, Berkeley, in 1960 and 1962, respectively.

Analysis of Massive Datasets

Chandrika Kamath, Session Chair

Center for Advanced Signal and Image Sciences

Estimating Missing Features to Improve Multimedia Information Retrieval

Abraham Bagherjeiran, Nicole S. Love, and Chandrika Kamath
UCRL-ABS-225087

Retrieval in a multimedia database usually involves combining information from different modalities of data, such as text and images. However, all modalities of the data may not be available to form the query. The retrieval results from such a partial query are often less than satisfactory. In this paper, we present an approach to complete a partial query by estimating the missing features in the query. Our experiments with a database of images and their associated captions show that, with an initial text-only query, our completion method has similar performance to a full query with both image and text features. In addition, when we use relevance feedback, our approach outperforms the results obtained using a full query.

Analysis of Rayleigh-Taylor Instability: Bubble and Spike Count

Chandrika Kamath, Abel Gezahegne, Paul L. Miller
UCRL-ABS-223676

The use of high-performance computers to simulate hydrodynamic instabilities has resulted in the generation of massive amounts of data. One aspect of the analysis of this data involves the identification and characterization of coherent structures known as "bubbles'" and "spikes". This can be a challenge as there is no precise definition of these structures, and the large size of the data, as well as its distributed nature, precludes any extensive experimentation with different definitions and analysis algorithms. In this talk, we describe the use of image processing techniques to identify and count bubbles and spikes in the Rayleigh-Taylor instability, which occurs when an initially perturbed interface between a heavier fluid and a lighter fluid is allowed to grow under the influence of gravity. We analyze data from two simulations, one a large-eddy simulation with 30 terabytes of analysis data, and the other a direct numerical simulation with 80 terabytes of analysis data.

Pattern Recognition for Massive, Messy Data

Philip Keglmeyer, Sandia National Laboratories
Sandia Pub #2006-3464 P

Modern data possess qualities that challenge, and even invalidate, traditional pattern recognition approaches. This is particularly true of the stockpile simulation data in the ASC program. Yet pattern recognition is a crucial component of the post-processing of ASC data at Sandia.

I will review these challenges, and show how they motivate the development of a new, "commodity" approach to pattern recognition, one that can handle data that overwhelms the previous "craftsman" model. I will present the core technical components of commodity pattern recognition (decision trees, new ensemble methods, and SMOTE), and discuss generalization to problems beyond ASC data.

Visualization and Analysis of 2D and 3D Image Data with VisIt

Mark C. Miller
UCRL-ABS-225664

VisIt is an open source, turnkey visualization product developed at LLNL. It supports visualization and analysis of a variety of scientific data including 2D images and 3D image volumes. In addition, it is designed to scale to extremely large data sizes and includes numerous features for visualization and analysis of scientific data in a variety of computing enviornments.

An overview of VisIt with emphasis on its features for 2D and 3D image data will be presented.

Visualization of Experimental and Numerical Data at the Sustained Spheromak Physics Experiment

Carlos A. Romero-Talamás, E. Bickford Hooper, Harry S. McLean, Reginald D. Wood, and Jeffrey M. Moller
UCRL-ABS-225018

The spheromak is a concept being investigated for the magnetic confinement of controlled thermonuclear fusion plasmas. Spheromaks are routinely produced at LLNL's Sustained Spheromak Physics Experiment (SSPX [E. B. Hooper, L. D. Pearlstein, and R. H. Bulmer. Nucl. Fusion, **39**:863, 1999]). A diverse set of plasma diagnostics, and in particular high-speed imaging and magnetic probes, are being used to understand how magnetic fields in the plasma self-organize to produce the spheromak configuration. Numerical simulations of SSPX plasmas from a three-dimensional, resistive, magnetohydrodynamic code called NIMROD [C. R. Sovinec, A. H. Glasser, T. A. Giankon, et al., J. Comp. Phys., **195**:355, 2004] are also used to investigate spheromak formation and sustainment. There is a great challenge in the processing, interpretation, and comparison of SSPX and NIMROD data due to differences in temporal and spatial resolutions of the different diagnostics, as well as the vast amounts of data produced by each instrument and the simulations. Visualization tools such as LLNL's VisIt [http://www.llnl.gov/visit/] help identify spatial and temporal areas of interest in the data. This information is then used to create specialized algorithms that search for events such as magnetic reconnection, which is necessary to form spheromaks. Examples of this data processing, visualization, and comparisons between experiments and simulations, will be presented.

Nondestructive Evaluation

Harry Martz, Session Chair

Center for Advanced Signal and Image Sciences

Morphological Algorithms for Non-Destructive Evaluation

Siddharth Manay, Sailes Sengupta, Aseneth Lopez, and Doug Poland
UCRL-ABS-225070

In this presentation, we describe the application of a well-known mathematical and image processing technique, morphology, to the problem of void detection in three-dimensional Computed Tomography (CT) images of machine parts. We outline an image processing pipeline that includes denoising, morphological operations, and post-processing to locate the desired defects. We then explore methods for computing a figure of merit of the detected defects, based on local image statistics, such as area and contrast, as well as a novel gradient direction measure in the sinogram domain. The figure of merit is then used for false positive rejection. We demonstrate our method on real CT images of a test object.

Fusion of X-Ray and Ultrasound Images for As-Built Modeling

Grace A. Clark and Jessie A. Jackson
UCRL-ABS-225363

The goal in the as-built modeling effort is to provide high-quality nondestructive evaluation (NDE) imagery of mechanical parts to colleagues doing finite element analysis (FEA). This requires depicting the locations and physical characteristics of material boundaries, as well as cracks, inclusions, voids, delaminations, ablations and other flaws. The X-Ray computed tomography (CT) images and Ultrasound test (UT) images used for NDE have performance strengths and weaknesses. For example, ultrasound images are useful for detecting closed cracks, but they have very low spatial resolution. On the other hand, X-Ray images have very high spatial resolution, but are not generally useful for detecting closed cracks. The goal of this work is to improve the probability of correct classification of flaws and the probability of a successful inspection by exploiting the strengths of both X-Ray CT and Ultrasound imagery. Fusion is greatly simplified if the images are co-registered. Currently, relatively little sensor fusion work has been reported in the NDE literature; largely because attempts to register images have led to great difficulty and limited success. The primary challenge lies in the fact that, unlike CT images, UT images are difficult to scale to dimensional units. Scaling requires estimating the sound velocities in the various materials, and locating acoustic events. Most other ultrasonic work (medical, etc.) is qualitative enough that such analysis is not necessary.

This work presents fusion results using real CT and UT images from a known "phantom" part in controlled experiments. The phantom consists of concentric cylinders of epoxy, aluminum, cellulose and air. The interface between cellulose and epoxy is not visible in the CT image, but it is clearly visible in the UT image (although its resolution is very low). The CT and UT images are registered manually, in the sense that the event location and velocity estimation processes are carried out by hand. Super-resolution algorithms are used to improve dramatically the spatial resolution of the UT images. This allows the creation of a UT "edge map" showing a high-resolution image of the locations of the material boundaries. This UT edge map is superimposed on the CT image to form a fused image that clearly shows all of the material boundaries. Future work involves automating the registration process and generalizing the fusion to deal with more complex scenarios.

Time Resolved Measurement of Transient Acoustic Waves Using a Frequency Domain Photoacoustic Microscopy System

Oluwaseyi Balogun and Todd. W. Murray
Aerospace and Mechanical Engineering Department,
Boston University, Boston, MA
UCRL-ABS-225869

Photoacoustic microscopy is a laser based inspection technique that allows for the non-contact measurement of the elastic properties of materials with high spatial and temporal resolution. In this technique, a pulsed or modulated continuous wave laser is used to irradiate a sample surface, where the laser energy is absorbed causing localized heating. The transient thermal stress field produced in the sample by thermoelastic expansion leads to the generation of coherent acoustic (elastic) waves. The displacement resulting from the acoustic wave interaction with the sample boundaries is measured using an optical detection system, and analyzed to characterize the elastic properties of the sample. A novel high-sensitivity photoacoustic microscopy system is presented which uses an amplitude modulated continuous wave laser for the excitation of acoustic waves. The modulation frequency of the excitation laser is swept over the bandwidth of interest, and transient signals are synthesized for the measured frequency domain data. Due to the extremely narrow bandwidth of the generated acoustic waves, the bandwidth of the optical detection system is appropriately reduced leading to significant improvements in signal to noise ratio (SNR). Femtometer scale displacement sensitivity is achieved using the photoacoustic microscopy system over a spectral range of 200 MHz. The SNR of the system is determined, and the effects of the sampling frequency of the measurement, detection bandwidth, and time domain aliasing on the unambiguous construction of the transient signals are discussed.

Micron Scale Resolution of Structural Features in Mesoscale Material Systems Using Laser Based Acoustic Microscopy

Oluwaseyi Balogun, Robert Huber, and Diane Chinn
UCRL-ABS-225870

Laser based acoustic microscopy is a high sensitivity, non-contact inspection technique used for materials characterization and nondestructive evaluation. In this technique, a pulsed laser is typically used for acoustic wave generation. The energy of the laser source is absorbed in a test sample, which leads to the transient heating of the material and the generation of acoustic waves by thermoelastic expansion. The sample displacement resulting from the acoustic wave interaction with the sample boundaries is measured using an optical detection system. Through measurement of the acoustic wave velocity, attenuation and dispersion, the mechanical, dimensional and micro-structural properties, of the sample can be characterized. In this work, a high frequency laser based acoustic microscope is developed to provide micrometer range spatial resolution for detecting sub-surface structural features in materials with thicknesses on the order of hundreds of microns. An immediate application of this system is for the characterization of the National Ignition Facility (NIF) targets. In order to achieve micrometer spatial resolution with the laser acoustic microscope, high frequency acoustic waves with frequencies around 1 GHz are used. Preliminary experimental results obtained with this system in several metal foils indicate that the high frequency acoustic waves can propagate in the metal foils. The high frequency acoustic waves attenuate due to geometric effects, sample surface roughness, local material anisotropy and micro-structural grain scattering. These effects are discussed in the presentation and their influence on the spatial resolution is detailed.

Super-Resolution Algorithms for Ultrasonic Nondestructive Evaluation Imagery

Grace A. Clark, Jessie A. Jackson and Steven E. Benson
UCRL-ABS-225376

The spatio-temporal range resolution of ultrasonic measurements is often severely limited by the inherent band-limited spectral transfer function of the ultrasonic transducers. This is manifested as ringing in the time domain. Practical super-resolution algorithms are presented for improving spatial resolution in one-dimensional (1D) pulse-echo signals (A-Scans) by mitigating transducer distortion.

Two-dimensional (2D) images (B-Scans) and 3D volumes are formed from suites of processed A-Scans. The algorithms sequentially perform system identification and spectrum extrapolation, two inverse problems that are ill-posed and ill-conditioned. Emphasis is placed on practical pre-processing steps, regularization schemes and a priori constraints that are used to ensure useful results in practice. The efficacy of the algorithms is demonstrated using real data from controlled experiments. Several different practical ultrasound applications are presented, showing improved location of material interface boundaries. The algorithms have also been applied to similar material layer problems using electromagnetic signals.

Surface Acoustic Wave Microscopy of Optics

Michael J. Quarry
UCRL-ABS-224904

The feasibility of surface acoustic wave microscopy to detecting fine cracking in NIF optics was investigated. Cracks occur in the surface of NIF optics from the grinding of the surface, and subsequent polishing still leaves fine cracks. An Olympus UH-3 acoustic microscope was refurbished to enable surface acoustic wave microscopy from 200 MHz to 1 GHz on fused silica. The system uses high frequency bulk and surface acoustic waves to characterize surfaces, near surfaces, and thin films. Feasibility studies were performed on fused silica with surface fractures from grinding and polishing. An acoustic lens is raster scanned over the surface of the optic to obtain an image of a 2 mm by 2 mm surface in about 10 to 15 seconds. The results show similar images to optical images of fractures of about 11 µm in length. The acoustic technique should be able to form the same images without etching.

Imaging Methodology

Mike Moran, Session Chair

Performance Modeling of the NIF Neutron Imaging System

Carlos A. Barrera
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UCRL-ABS-224958

The Neutron Imaging System (NIS) for the National Ignition Facility (NIF) is currently under development. The system should be able to record hot-spot (13 – 15 MeV) and cold-fuel (6 – 10 MeV) images with a resolution of 10 microns and a signal-to-noise ratio (SNR) of 10 at the 20% contour. This diagnostic is valuable because lower energy neutrons reveal the distribution of the non-burning DT fuel surrounding the hot-spot, providing key information in the case of a failed implosion. An End-to-End model of the system has been developed to study the performance of different designs with respect to the resolution and SNR requirements. The model includes accurate source distributions of a failed implosion, five aperture geometries (ring, penumbral, square pinhole, small penumbral pinhole and triangular wedge), their associated point spread functions, and a pixelated plastic scintillator detector array. The simulated recorded images are deconvolved using a modified regularization algorithm, producing overall simulations of the expected source images.

Coherent Addition of Pulse for Energy (CAPE) Instrument and Data Fitting Model Study

Michael C. Rushford, Stanley Davis[1,2], Antonio Lucianetti, Igor Jovanovic,
Curtis G. Brown, Craig W. Siders, Wayne Brewer, Mike Taranowski, Jose Hernandez, and Christopher P.J. Barty
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UCRL-ABS-225307

National Ignition Facility (NIF) uses laser beam heated metals to make X-Ray back light pictures of fusion core compression symmetry. These core densities are starting to be transparent for short wavelength X-Rays ~>40Kev. This can be achieved by driving the back-lighter plasma to higher temperatures with higher laser power. Inertial Confinement Fusion (ICF) can be more efficiently implemented via fast ignition. It uses a short pulse to generate a particle beam to efficiently spark-initiate the compressed fusion target to thermonuclear burn. Reaching the needed laser power is limited by the optic aperture power that can be transported. If multiple adjacent short pulse apertures are combined at a focal point, then a pathway to increasing the focal spot power of short pulse experiments increases again. The Advanced Radiographic Capability (ARC) on NIF has 2 then 4 and 8 possible beam paths which can be combined; we call this Coherent Addition of Pulses for Energy (CAPE).

Coherently overlapped focal spots offer interference fringes which encode the degree of simultaneity of two pulses. This talk explores an interferometer and the data analysis used to measure the dispersion difference between pulses at a common focus.

A modeled double slit spectrometer interferogram was measured via phase stepping to show this procedure unambiguously finds the white light interference fringe (stationary phase point).

This study shows a possible way to ensure centering a constructive interference fringe on a coherently combined focal spot with 10th wave (0.3 fs) uncertainty.

Curvature Wavefront Sensing Using an Extra-Focal Image and an Intra-Focal Image of a Bright Star

Donald Phillion, Kevin Baker, Stacie Hvisc

UCRL-ABS-225619

Curvature wavefront sensing (CWFS) is a phase retrieval method that uses two intensity images in the regime where the Transport of Intensity (TIE) Equation is valid. We discuss a generalization of the matrix method presented in Gureyev's and Nugent's 1996 J. Opt. Soc. Am. A paper. Wave optics simulations have been used to generate the two intensity images from which the phase is to be reconstructed. These images are averaged both over a wavelength band and over time as a Kolmogorov atmospheric phase screen moves by. CWFS can be implemented either by pistoning the focal plane and observing the same star at different times at different z-positions or by splitting the focal plane, offsetting the two sub-areas plus and minus in z, and observing two different stars at the same time in the two focal plane sub-areas. Splitting the focal plane has the disadvantages of requiring registration and requiring a correcting for any difference in vignetting between the two images. If there are other stars nearby whose out-of-focus images overlap the out-of-focus images of the stars being used, then the errors in the reconstruction are much greater than if a single star were observed with the focal plane in two different positions. Furthermore, if the CWFS is operated curved loop, the errors will converge to zero for the same star case, but will not converge to zero for the different star case. If the telescope is operated without an atmospheric dispersion corrector (ADC), then the errors will again be much greater for the different star case and will not converge to zero closed loop.

The Compact Compton Imager: A Spectroscopic, Large Field-of-View Gamma-Ray Camera

Lucian Mihailescu, Morgan Burks, Daniel Chivers, Karl Nelson, Kai Vetter

UCRL-ABS-225319

The Compact Compton Imager (CCI) is a gamma-ray imager based on Compton scatter camera principles being developed at Livermore. The imager is based on position sensitive, double sided segmented planar HPGe and Si(Li) detectors. These detectors provide excellent spectroscopic and imaging capabilities. We describe data analysis and image reconstruction methods used for obtaining large field of view images. The spectroscopic capability of the employed detectors of 2keV FWHM insures a precise identification of the imaged radioactive elements. The CCI system was shown to provide an imaging angular resolution of 2 degrees with a field of view that approaches 4π. We also report on a test measurement in which the gamma-ray imager was combined with a lidar scanner for directly identifying objects containing extended radioactive materials. The CCI gamma-ray imaging system is expected to find useful applications in homeland security applications, nonproliferation and material management applications, biomedical imaging.

This work was sponsored by the Office of Research and Development/Department of Homeland Security.

Distributed Object Classification in an Imaging Sensor Network

Leo Szumel, UC Davis

In a distributed sensor network that is capable of collecting and analyzing visual information, it is imperative to minimize communication between nodes. We accomplish this by analyzing the video close to the sensor, and sending summary information over the radio. An existing network, DISCERN, has been developed at Sandia and is capable of predicting object movement and communicating this information to neighboring nodes.

Movement prediction is the first step in track analysis. We would like to perform additional, and configurable, high-level processing inside the network whenever possible. Processing inside the network reduces the volume of data which must be sent outside the network. Two challenges arising from this goal are: (1) different objects will require different tracking algorithms and (2) the algorithms will likely evolve over time as more information is collected and new object classes are defined.

In previous research on dynamically tasked sensor networks, I developed an agent-based programming model. In this model, individual tasks are embodied in agents, which are entities composed of both code and data and capable of self-replication in the network. I found that such a model can work well for object tracking because specific objects can be tracked by specially-tailored agents, and these agents can be updated independently of each other when necessary.

I am currently in the process of implementing my programming model on the DISCERN sensor node and will have preliminary results to present at CASIS. I intend to implement simple object classifiers for two classes of objects, A and B. Two special agents, one for each object type, will collect statistics on objects as they move around the network. Once an agent has collected sufficient information to make a classification, it will transmit its information and conclusion to a remote server. The DISCERN nodes are capable of calculating object centroid and movement vector, so I plan to use those two statistics as inputs two the agent algorithms.

Virtual Geographic Routing

Michael E. Goldsby, Sandia National Laboratories
Sandia RA# 5247572

Virtual Geographic Routing (VGR) is an ad hoc routing protocol that is scalable to massive numbers of nodes. It does geographic routing using virtual coordinates in a K-dimensional space.

Geographic routing works on a simple principle: At every hop, a message is forwarded to a neighboring node that is geographically closer to the destination. The advantage of geographic routing is that it requires only a small amount of storage at each node for routing information and thus is massively scalable.

A disadvantage of geographic routing is that the nodes must know their locations in space; this typically requires GPS units, which increase the size, weight, cost and power consumption of the nodes and cannot function indoors.

VGR replaces the x, y coordinates of real geographic routing (RGR) with K virtual coordinates and uses a Euclidean distance metric over them. The virtual coordinates are developed solely from network connectivity information, so there is no need for GPS units. The virtual coordinates are the number of hops from K self-selected anchor nodes. We develop the coordinates using an algorithm similar to the distributed Bellman-Ford algorithm.

Geographic routing fails when it encounters a local minimum, a node at which no neighbor is closer to the destination than itself. There are various way to compensate for this failure. The method we use here is to use an expanding ring search for a node closer to the destination that the current nodes; that node then becomes an intermediate destination. Results of the search are cached in order to minimize communication overhead.

VGR also displays a phenomenon we call aliasing: Two nodes with different node identifiers can have the same virtual coordinates. Since such nodes can be several hops apart, aliasing causes a problem for the routing algorithm. We use an expanding ring search to deal with this problem, too, again caching the result.

Using simulation on random node layouts in two spatial dimensions, we show that the performance of VGR is comparable to that of RGR and somewhat better in the presence of barriers to transmission.

Neither VGR nor RGR develops shortest paths between source and destination, although the average path length approaches the average shortest path length as the average node degree of the communication graph increases.

The main factor affecting the scalability of VGR is the amount of local storage used for the routing cache. As the average node degree rises above about 8, the cache usage of both VGR and RGR tends to approach a constant.

In the presence of barriers to transmission, RGR is much more susceptible to local minima than VGR. If we classify hops as either "geographic" or "special" (used to find or take routes around local minima or to find or use paths to aliased nodes), we find that RGR has a far greater proportion of special hops than VGR when barriers are present.

NIF Optics Inspection

Laura Kegelmeyer, Session Chair

NIF Optics Inspection Analysis

Laura Kegelmeyer, Stephen G. Azevedo, John W. Carlson, Steven M. Glenn, Judy A. Liebman

UCRL-ABS-225280

NIF Optics Inspection consists of acquiring and analyzing images from thousands of optics both on and off the NIF beamline. Optics are inspected to assure quality before being installed and are continually monitored once on the beamline.

The Optics Inspection Analysis team has been developing automated methods to track the condition of each optic throughout its lifetime.

We provide analysis to support

- off-beamline laboratories that inspect optics for QA
- off-beamline laboratories that condition optics to strengthen them
- on-beamline commissioning & hardware evaluation
- high level reporting of the condition of optics on (up to 192) beamlines
- prediction codes that determines when optics should be recycled
- detailed reporting for an optic, with ability to track a flaw through time
- off-beamline laboratories that take micrographs, phase sensitive and other measurements for flaw sizing and characterization

We have a large central database at our core, integrating image analysis, statistics, pattern recognition, optical physics theory, decision-making and data visualization for a unified inspection system, equally accessible to all customers.

Here, we present an overview of the scope of our work as well as some detailed views of new efforts this year, including performance enhancements, infrastructure modifications, image registration techniques for tracking defects, and using the results of the FRODO (Finding Rings of Damage on Optics) project to inspect the quality of optic coatings. We'll also explain how OI Analysis software is used in practice for the NIF.

NIF Optics Damage Inspection Systems

Alan Conder

UCRL-ABS-225561

The Precision Diagnostic System (PDS) is the National Ignition Facility (NIF) diagnostic beamline and uses final optics that are identical to those fielded at the target chamber on the NIF laser. The PDS Final Optics Damage Inspection (PFODI) system is a specialized camera and software system that inspects the PDS beamline optics for laser induced damage, with special attention paid to the high value final optics– the doubler (SHG), tripler (THG), wedged focus lens (WFL) and the main debris shield (MDS). In this presentation, we will describe the results for the PFODI system obtained during the FY06 PDS campaign with a discussion of the techniques used to estimate the diameter of defects many times smaller than the resolution limit of the system.

Parrallel Image Processing for NIF Optics Inspection

Steve Glenn, Judy Liebman, Steve Azevedo, John Carlson, Laura Kegelmeyer
UCRL-ABS-225212

NIF Optics Inspection will generate large numbers of images that must be analyzed within a tight time window in order to achieve NIF operational goals. Previous efforts have concentrated on serial analysis of images acquired from a relatively small number of beam lines - an approach that will not meet operational requirements when all 192 beams are available. To solve this problem, we have implemented a Linux-based parallel processing system for NIF Optics Inspection using the SLURM package developed at LLNL. This presentation will review the NIF Optics Inspection computing architecture, introduce the SLURM package, and describe how existing analysis code was adapted to work within a parallel processing environment.

Performance Improvements in NIF Optics Inspection Software

Philip Fong, Steven Glenn, Judith Liebman, and Laura Kegelmeyer
UCRL-ABS-225279

Images of optics in the National Ignition Facility (NIF) are acquired and analyzed on an ongoing basis to detect and monitor potential defect sites. The Optics Inspection (OI) Software must be able to process a large number of images and provide timely feedback to users and operators of the facility.

The NIF OI Analysis software consists of a framework for automatic handling and analysis of the images. The analysis portion is written in the MATLAB programming environment and consists of a pipeline of algorithms to detect defects, determine their extent (area) and then make measurements on the defined defect so they may be tracked over time.

Here, we present techniques for improving the speed and accuracy of the detection and area determination steps. First, the detection algorithm, which has been described in previous CASIS workshops, seeks objects that stand out from the background by computing the signal to noise ratio over gaussian weighted windows (GSNR) for each pixel in the image.

A key image filtering step done with MATLAB's Image Processing Toolbox routine "imfilter", represented a timing bottleneck,accounting for a vast majority of the runtime for the GSNR routine. Replacing the call to imfilter with a more efficient implementation resulted in one-sixth the runtime for detection. A comparison of the advantages and disadvantages of several developed alternatives is presented.

Second, once a potential defect is detected, the software must determine its extent in order to make measurements and yield enough information to decide on the status of this hypothesized defect. The most intense pixel value for each group of connected pixels found by the detection process is called a seed. The previous method blindly included any neighboring pixels that were within 50% of the intensity of seed intensity, sometimes including pixels from brighter noise areas in the definition of the defect. We will describe a new adaptive method that determines the cutoff percentage for each object dynamically, thus virtually eliminating falsely large defects. Improved performance, as measured by a more accurate representation of true positives will be demonstrated using simulated image data and a decrease in the area covered by false positive detections in real NIF images. Additionally, we will discuss the latest performance demonstrated on the NIF beamline.

Ultrasonic Shear Wave Imaging of Optic Features

Michael J. Quarry
UCRL-ABS-224917

When complete, NIF will be the world's largest and most energetic laser and will be capable of achieving for the first time fusion ignition in the laboratory. Detecting optics features within the laser beamlines and sizing them at diameters of 100 µm to 10 mm allows timely decisions concerning refurbishment and will help with the routine operation of the system. Horizontally polarized shear waves at 10 MHz were shown to accurately detect, locate, and size features created by laser operations from 500 µm to 8 mm by placing sensors at the edge of the optic. The shear wave technique utilizes highly directed beams. The outer edge of an optic can be covered with shear wave transducers on four sides. Each transducer sends a pulse into the optic and any damage reflects the pulse back to the transmitter. The transducers are multiplexed, and the collected time waveforms are enveloped and replicated across the width of the element. Multiplying the data sets from four directions produces a map of reflected amplitude to the fourth power, which images the surface of the optic. Surface area can be measured directly from the image, and maximum depth has been shown to be correlated to maximum amplitude of the reflected waveform.

Model-Based Signal Processing and Estimation

David Chambers, Session Chair

Detection of Seismic Events with Model-Based Signal-Processing

Arthur Rodgers, David Harris and Michael Pasyanos
UCRL-ABS-225122

Recently, coherent signal-processing methods, such as match filtering and subspace methods, have produced great advances in reducing detection thresholds for earthquakes and explosions. These methods work well when empirical observations of past events are available. In many cases, however, these empirical observations are not available. Here, we have demonstrated that model-based signals (i.e. synthetic seismograms) can be used as templates for coherent signal-processing using the subspace method. We compute a basis of synthetic signals for a regional network of sensors for a hypothesized source event at a particular location using stochastic earth models generated from a Markov-Chain Monte Carlo process (using the Stochastic Engine). We use a singular-value decomposition of these basis signals to construct a minimal representation for a waveform subspace spanning the range of signals anticipated for the source event under the uncertainty of the geophysical models. We operate a detector by projecting into this subspace the data from a window running along the waveforms streaming from the sensor network. The operation forms a running correlation coefficient of the data with the best linear combination of basis waveforms comprising the subspace representation. When the correlation exceeds a threshold value, a detection can be declared. We have demonstrated the feasibility of model-based signal-processing for detection of seismic events at regional distances (200-1000 km). This method promises to reduce thresholds for detecting nuclear explosions in areas where no prior observations of explosions exist.

Model-Based Layer Estimation Using a Hybrid Genetic/Gradient Search Optimization Algorithm

David H. Chambers
UCRL-ABS-224881

A particle swarm optimization (PSO) algorithm is combined with a gradient search method in a model-based approach for extracting interface positions in a one-dimensional multilayer structure from acoustic or radar reflections. The basic approach is to predict the reflection measurement using a simulation of one-dimensional wave propagation in a multi-layer, evaluate the error between prediction and measurement, then update the simulation parameters to minimize the error. Gradient search methods alone fail due to the number of local minima in the error surface close to the desired global minimum. The PSO approach avoids this problem by randomly sampling the region of the error surface around the global minimum, but at the cost of a large number of evaluations of the simulator. The hybrid approach uses the PSO at the beginning to locate the general area around the global minimum then switches to the gradient search method to zero in on it. Examples of the algorithm applied to the detection of interior walls of a building from reflected ultra-wideband radar signals are shown. Other possible applications are optical inspection of coatings and ultrasonic measurement of multilayer structures.

Introduction to Particle Swarm Optimization

Sean K. Lehman
UCRL-ABS-225262

Particle swarm optimization (PSO) is easily described by two equations which describe, in an *ad-hoc* manner, the paths of a flock of birds or school of fish (the "particles") as they navigate an *n*-dimensional space when searching for food:

$$v_n(t+1) = \phi(t)v_n(t) + \alpha_1\gamma_{1n}(t)\left[p_n - x_n(t)\right] + \alpha_2\gamma_{2n}(t)\left[G - x_n(t)\right] \quad (1)$$

$$x_n(t+1) = x_n(t) + v_n(t) \quad (2)$$

where

n	is the number of particles;
t	is the time step;
$x_n(t)$	is the location of the n-th particle at time t;
$v_n(t)$	is the velocity of the n-th particle at time t;
$\phi(t)$	is the "inertia" function;
α_1 & α_2	are "acceleration" constants;
$\gamma_{1n}(t)$ & $\gamma_{2n}(t)$	are $[0,\ 1]$ uniformly distributed random numbers;
p_n	is the n-th particle's best location;
G	is the entire swarm's best location.

In this gradient-free, biologically-inspired optimization method, each particle "remembers" its best location and compares it with the entire swarm's global best location as they navigate the space. In this manner, they are able to achieve a locally best solution without the use of gradients and, in some cases, fewer function evaluations. We review the theory behind PSO, discuss the significance of the model and its components, and present examples.

A Single-Layer Network of Unscented Kalman Filters Adaptively Fused by the Mixture-of-Experts Method

Eric Breitfeller
UCRL-ABS-225510

The unscented Kalman filter (UKF) is replacing the extended Kalman filter (EKF) in many applications. It is worthwhile then to revisit a fairly robust method of tuning filters as it applies to the UKF. The mixture-of-experts (MOE) method is used to adaptively fuse the outputs of a bank of differently tuned filters. The variation among the tuning of the filters commonly arises due to a lack of knowledge of the exact parameters that represent the system plant and sensors. In the case of the EKF, and considering only plant and sensor noise contributions (e.g., ignoring unmodeled control inputs), this would allow the designer to choose variations for the plant covariance noise term ("Q") and the sensor covariance noise term ("R") from which to construct a network of EKFs. The same tuning parameters apply to the UKF, and in addition, it may be possible to tune the parameters associated with calculating the sigma points in order to more accurately capture non-Gaussian distributions.

Measurement Uncertainty for Automatic Alignment Algorithm

Abdul Awwal, Clement Law and Walter Ferguson
UCRL-ABS-225440

Automatic alignment algorithms determine the position of the laser beams by processing the video images of the NIF laser beams. These algorithms range from weighted centroid to those based on matched filters. The tolerances in the lenses, wavefront aberrations of phase and amplitude and other optical effects may make the beam nonideal. In addition, detector noises and noise introduced by optical defects could also modify the beam in some way that may affect the calculated beam location. All these effects result in an uncertainty about the beam position measurement. Appropriate magnitude of uncertainty is necessary for safe alignment operation in the NIF system. This work describes our ongoing effort to quantify this uncertainty.

Spectral Analysis Options

Karl Nelson
UCRL-ABS-225521

This talk presents a brief introduction to the problems of automated spectral dentification for NaI(Tl) scintillators including problem introduction, a review of current approaches to the problem, and an evaluation of template based approaches. Evaluations show the relative performance for a field deployable nuclide identifiction code (GADRAS) and a classical estimator as well as a principle components based classifier. Evaluation methodology used for comparison of algorithms is presented.

Image Processing and Analysis

Dave Paglieroni, Session Chair

Center for Advanced Signal and Image Sciences

Review of the State of the Art in Image Registration

Judy Liebman, Stephen Azevedo, John Carlson, Steven Glenn, Laura Kegelmeyer
UCRL-ABS-225256

Image registration is fundamental to analyzing most multi-image based data. It is also an extremely varied problem which depends on the types of images and information to be registered. In order to solve this important yet diverse problem there has been a plethora of research in registration over the past 30 years. In this talk we will review the most robust and versatile registration algorithms from the literature and discuss which specific types of image data they each address best.

We will start with image-based registration techniques such as correlation, and go on to many of the feature based registration algorithms. The feature based algorithms include those that search the transformation space to find the best fit between the point sets, and those that search the space of all possible connections between points.

Several of these algorithms have been used by the NIF Optics Inspection project to register images of optics inside the NIF laser taken at different times. Optics Inspection relies on the registration results to track defects on an optic throughout the lifetime of the optic. Results and performance comparison from applying these registration algorithms to NIF will be presented.

Progressive Dense Correspondence with Applications to Video Analysis

Mark Duchaineau
UCRL-ABS-225824

An iterative algorithm has been developed to find dense (per pixel) geometric mappings from the domain of a source image such that it matches a target image at the mapped locations. The algorithm proceeds from coarse to fine scales in the pixel resolution pyramids of the two images, and the mapping resolution pyramid. The two alternating phases of computation at each resolution level include an optical-flow-style gradient descent phase performed independently at each source pixel, and a mapping mesh relaxation/straightening phase over adjustable sized neighborhoods around a pixel (up to a global least squares fit if desired). Operations and processing was designed to map well to computation on graphics processing units (GPUs), which show over 100x performance gain compared to a straightforward CPU implementation. Applications demonstrated stabilization of aerial video taken from a moving camera, resolution enhancement by overlaying multiple video frames, and background/mover segmentation.

A Linear Consolidation Approach for Automatically Extracting Roads of Variable Widths from Overhead Images

Barry Y. Chen, David W. Paglieroni and Faranak Nekoogar
UCRL-ABS-224911

We present a novel hierarchical approach for the extraction of roads of variable widths from overhead images based on consolidating and connecting ensembles of nearly parallel line segments. This fully-automatic approach extracts information at levels of increasing complexity. At each level, the algorithm builds upon the information extracted at lower levels, filtering out false hits from previous levels and gradually homing in on roads. At the lowest level of the hierarchy, a dense edge map is extracted from the image by finding pixels that are local maxima in gradient magnitude. Next, connected edge pixels forming longer and straighter curves are extracted using an efficient gradient-direction channel de-cluttering algorithm. These curves are approximated by piecewise linear segments. Consolidating ensembles of nearly parallel line segments that are close together both laterally and longitudinally results in thick line segments that represent individual sections of roads. Finally, road networks are extracted by connecting the thick line segments and discarding those that are not members of long networks. We demonstrate results of our algorithm at each level in the hierarchy on images of varying resolution in rural and urban settings.

Algorithms for Fast, Robust Model-Based Polygon Detection

Siddharth Manay and David Paglieroni
UCRL-ABS-224957

In this presentation we detail a fast, hierarchical method for extracting polygons from images. We present a simple, flexible, rotationally invariant polygon model. We first extract corners from the image using Gradient Direction Matching. In addition to location, the corners are described by orientation and acuteness. Corners are then grouped into trees of connected corners, constrained and pruned using the polygon model. These trees are then searched for closed polygons and incomplete/partial polygons. Candidate polygons are ranked using a figure of merit based on both geometric and gradient direction information. The polygon ranking as well as other criteria are used to filter and disambiguate the polygon matches. We demonstrate the method on real overhead imagery.

NOTES

NOTES

Signal and Imaging Sciences Workshop Survey
November 16 – 17, 2006

Thank you for attending the Signal and Imaging Sciences Workshop. We would appreciate your input for future workshops.

1. Length of the presentation at the CASIS Workshop:

   ______ Too long
   ______ Too short
   ______ Just right

2. Topics/issues you would like to see in future workshops:

3. Suggestions for next year's keynote speakers:

4. General comments/suggestions?

5. Please rank the overall Workshop as follows:

   ______ Excellent
   ______ Very good
   ______ Good
   ______ Fair
   ______ Poor

Please return this form at the end of the Workshop or send to Vickie Abreu at L-290 or email at: abreu2@llnl.gov.

Thank you,
CASIS Staff
http://casis.llnl.gov

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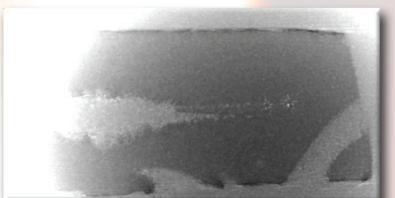

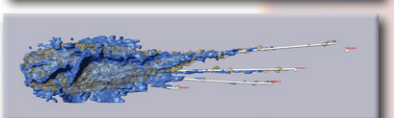

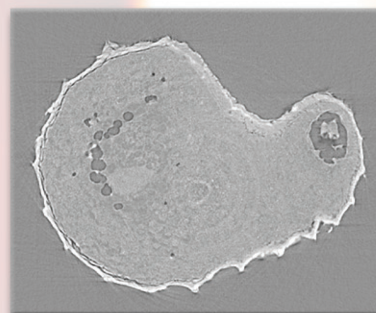

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